THE IMPACT OF THE UKRAINE WAR ON ANTARCTIC GEOPOLITICS THROUGH FUZZY COGNITIVE MAPS

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1 Introduction

The Antarctic continent holds the equivalent of 70% of the world's freshwater, over 170 types of minerals, and large deposits of natural gas (Andrade et al. 2018). Its surrounding area is an alternative navigation route due to its proximity to the southern hemisphere continents. Due to these characteristics, Antarctica, South America, the South Atlantic, and the countries of the western African coast have been included in Brazil's Strategic Environment, being areas of priority interest in the National Defense White Paper (Brazil 2016) and the National Defense Policy (Brazil 2020).

The Treaty of Antarctica was signed in 1959 by countries that claimed possession of parts of the Antarctic continent but agreed to suspend their claims indefinitely, allowing the freedom of scientific exploration of the continent under an international cooperation regime. The treaty came into effect in 1961, and Brazil joined in 1975. Subsequently, with the creation of the Brazilian Antarctic Program (PROANTAR)[3], Brazilian scientific research

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3 Established on January 12, 1982, the Brazilian Antarctic Program (PROANTAR) aims to promote diverse and high-quality scientific research in the Antarctic region with the purpose of: understanding the phenomena occurring there that have global repercussions, particularly on Brazilian territory; and ensuring the country's status as a Consultative Member of the Antarctic Treaty, achieved in 1983, which guarantees Brazil's full participation in the respective decision-making processes. PROANTAR uses the Antarctic Operation (OPERANTAR) as an operational arm for implementing the National Policy for Antarctic Affairs (POLANTAR), whi-

in the region was intensified, supporting the country's full participation in the Antarctic Treaty Consultative Meetings (ATCM), the treaty's main decision-making forum (Andrade et al. 2018).

The Antarctic Treaty sought to curb territorial interests that could drive military activities in the region. Thus, in 1987, Brazil conceived the National Policy for Antarctic Affairs (POLANTAR) "with a goal to achieve the country's objectives in Antarctica, considering the commitments assumed within the framework of the Antarctic Treaty System (STA)[4]" (Brazil 2022b). The National Defense Policy also emphasizes the exploration of Antarctica exclusively for scientific research purposes, with the preservation of the environment and its maintenance as a heritage of humanity (Brazil 2020).

Although geographically isolated, the Antarctic Continent is not exempt from the consequences that involve the countries that are signatories to the Treaty, which carry out research and have explicit interests in that region. The still ongoing Ukrainian War is part of this context, as it reignites animosity between the USA, Russia and China. This presents the potential for instability in the international system, capable of impacting other important strategic regions, which include Antarctica (Press 2022; McGee, Edmiston, and Haward 2022b).

This research evaluates possible geopolitical impacts resulting from the Ukrainian War on the STA. Although these events are apparently isolated from each other, the study shows that there are common aspects that influence each other in a complex network of interactions. As it involves events that are still ongoing, the research is relevant for bringing to light a series of driving forces (FM) with high potential for influence in the medium and long term, capable of promoting militarization initiatives on the continent. This assessment is also important for Brazil, as the scenarios raised have impacts on a region in Brazil's strategic surroundings. Additionally, the results of the study may lead to the ratification of objectives or provoke an eventual

ch establishes the country's principles and objectives in the region. PROANTAR is coordinated by the Interministerial Commission for Marine Resources (CIRM) and has four branches: scientific, environmental, logistical, and foreign policy, coordinated respectively by the Ministry of Science, Technology and Innovations (MCTI) and the National Council for Scientific and Technological Development (CNPq); the Ministry of the Environment (MMA); the Ministry of Defense (MD); and the Ministry of Foreign Affairs (MRE). It is the responsibility of these ministries to work together to implement POLANTAR (Brazil 2022b).

4 The Antarctic Treaty was the embryo of a more comprehensive system, which evolved from its fundamental points – exclusively peaceful use of the continent, freedom of scientific research, freezing of territorial issues – into a complex set of rules and instruments dealing with a wide range of topics, giving rise to what is now known as the Antarctic Treaty System (STA) (Aguiar and Mattos 2018).

reorientation of the Brazilian Antarctic Program. This research contribution aligns with Strategic Defense Action n. 83, which establishes the need to "increase Brazilian participation in decisions about the fate of the Antarctic region" (Brazil 2020).

Initially, the study approached the Treaty of Antarctica and its importance for the country, investigated international interests in Antarctica and expressed possible impacts of the Russo-Ukrainian War, composing a complex system with FM derived from these issues. The cause-and-effect relations between these FMs were evaluated by 28 geopolitical experts, with experience in PROANTAR activities. This later system was modeled by an artificial intelligence algorithm called Fuzzy Cognitive Maps. The results showed the evolution or regression of these forces in the face of favorable and critical scenarios on the maintenance of the Antarctic continent under the current condition of the Treaty.

2 The Antarctic Treaty and its importance for Brazil

The Antarctic continent has extreme characteristics. With 13,661,000 km2 (equivalent to 1.6 times the area of Brazil), it has an average temperature between -30 oC in the summer and -60 oC in the winter. High pressure centers and cold fronts influence the climate of several continents, especially South America. The accumulation of ice means that Antarctica has the equivalent of 70% of the planet's freshwater. Câmara and Melo (2018) describe the possible existence of oil, natural gas, rare and precious metals. Colacrai (1998) mentions reserves of gold, silver, cobalt, nickel, tin and uranium. Thorp (2012) estimates reserves of 50 billion barrels of oil in the Ross and Weddell Seas. The region also has a large quantity of krill, which is part of the Antarctic zooplankton, and is the basis of the ocean food chain (Mattos 2014). The location of Antarctica is also strategic, as it passes international maritime routes in the Drake Passage and the Cape of Good Hope, which connect the Pacific, Atlantic and Indian oceans (Câmara e Melo 2018). This set of strategic characteristics aroused the interest of several countries.

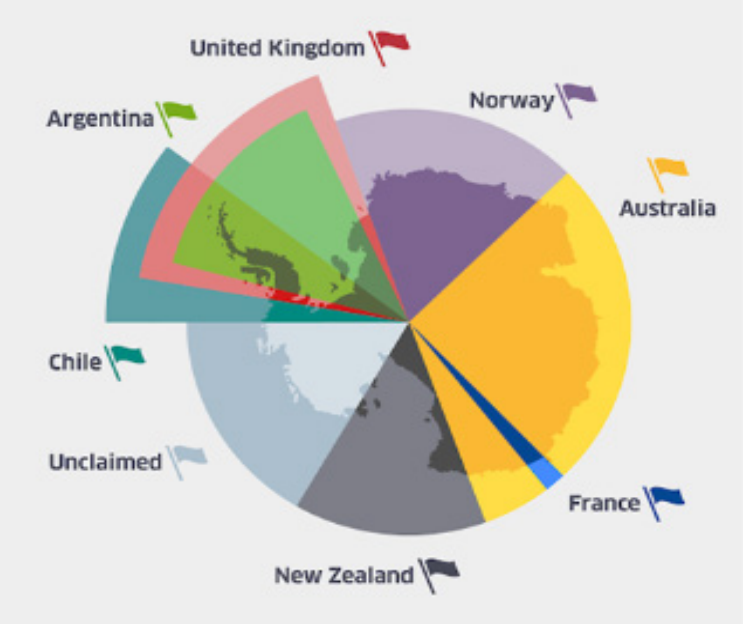
Due to its distance, characteristics and climate, the Antarctic continent began exploration late. Andrade et al. (2018) describes that the first reports of activity in the region date from the end of the 18th century to the mid-19th century, with the exploration of Antarctica and its surroundings by commercial interests that aimed to obtain seal skins and whale oil. At the beginning of the 20th century, commercial polar exploration began to be replaced by exploratory and scientific bias (Andrade et al. 2018).

With an increase in expeditions to the region, territorial claims began. Several theories used to justify ownership rights were developed:

the Discovery Theory. according to which the countries that initially found and explored Antarctic lands would have the right; the Theory of Contiguity and Continuity, which would give rights to the closest States; the Theory of Sectors, which implies the division of Antarctica into sectors defined based on the interface of States with the continent; the Defrontation Theory, supported by Brazilian geopoliticians Teresinha de Castro and Meira Mattos, according to which the facing countries in the Southern Hemisphere would have the right to sectors of the continent according to the southern projection of their respective coastal landmarks to the East and West over the region. There is also Effective Occupation, which attributed the right to portions of Antarctica to countries that effectively occupied the continent with scientific activities such as research, expeditions and permanent or temporary bases (Vieira 2006).

Based on these theories, several countries presented their territorial claims, as shown in Fig. 1. The United Kingdom, in 1908, was the first to claim territory, followed by New Zealand (1923), France (1924), Australia (1933) and Norway (1939) (Mattos 2014).

Figure 1 – Territorial Claims in Antarctica



Source: Andrade et al. (2018).

In 1940, Argentina and Chile formalized their territorial claims. There were coincidences between their areas and those of interest to the

United Kingdom. In 1949, the countries signed a joint declaration, according to which they committed not to send warships to the region. There was, however, a dispute between Argentina and the United Kingdom in 1952, which was resolved by diplomatic means, demonstrating the risk, however, that new incidents would occur (Mattos 2014).

The issue of the occupation of Antarctica gained momentum with the end of World War II, when disputes between Argentina, Chile and the United Kingdom intensified. In parallel, the Cold War motivated the USA and the former USSR by increasing their zones of influence and, consequently, the fear of conflict in the region. Furthermore, there was a fear, on the part of countries with territorial claims, that a proposal for the internationalization of Antarctica, led by India, would prosper (Castro 1976). As a result, Chile presented the Declaration of Escudero, which was the basis of the Treaty of Antarctica and which suggested "a moratorium on territorial claims; an agreement for the exchange of scientific data; and a declaration that stations and expeditions to the region would not constitute grounds for future claims" (Mattos 2014, 171).

In 1959, at the invitation of the USA, 12 countries met in Washington to study and propose a single legal regime for the sixth continent. Thus, the Treaty of Antarctica was signed on December 1, 1959, by the original signatories: Argentina, Australia, Belgium, Chile, United States, France, Japan, Norway, New Zealand, United Kingdom, South African Republic and the former USSR. These countries were those that, at the time, had the greatest representation in research, expeditions and the establishment of scientific stations in the region. The Antarctic Treaty came into force on June 23, 1961, following ratification by the original 12 signatories. It should be noted that Brazil was not part of the signing, as it was not carrying out relevant scientific activities at the time (Mattos 2014). Despite the formal complaint sent by the country, the lack of strategic vision and interest demonstrated at the time prevented Brazil from obtaining the status of original member and signatory of the Antarctic Treaty (Medeiros and Mattos 2019; Mattos and Câmara 2020).

In the Treaty of Antarctica, some articles mark the peaceful character of the continent: Art. I determined that the continent has a favorable and specific use for research and prohibits the establishment of bases or the carrying out of military exercises, except those that are to support research; Art. II specifies freedom of scientific research in the region and promotes international cooperation; Art. IV establishes the freezing of territorial claims; and Art. V prohibits weapons testing, including nuclear weapons (Hanessian 1960).

Despite being explicit in its text, territorial demands were not closed

when the Treaty of Antarctica was signed. There is also concern about possible dual[5] use of scientific support stations, according to Art. I, Item 2: "This Treaty shall not prevent the use of military personnel or equipment for scientific research or for any other peaceful purpose", with the potential for a veiled militarization of the continent (Hanessian 1960).

In the functioning of the STA, it is important to understand the role of the ATCM[6] which meets annually to decide on the main issues involving the continent (Wanlu 2021). Two groups are part of it: the consultative members who have voting and veto rights, which are made up of the 12 original signatory countries and another 17 countries that maintain relevant scientific activities in the region, such as expeditions and maintenance of research bases. In addition to these countries, there is a group of 24 non-consultative members, who appear on the ATCM councils as listeners and without voting rights (Molenaar 2021). Brazil is part of the consultative members of ATCM, due to its activities on the continent, which corroborate the existence of PROANTAR (Brasil 2016).

Another aspect to highlight in the STA is the Madrid Protocol, which establishes guidelines for the continent's environmental use and ultimately prevents the exploitation of natural resources. It was signed on October 4, 1991, and came into force on January 14, 1998 (Bastmeijer 2018). The "Madrid Protocol granted Antarctica the status of 'International Natural Reserve dedicated to Science and Peace' and can only be modified in 2048, as long as there is unanimous agreement from the consultative members of the Antarctic Treaty" (Brasil 2016). After this period, at the request of one or more advisory members, it may be revised, becoming more flexible and permissive to issues involving authorization for the exploitation of natural resources.

Table 1 illustrates the investment and engagement of consultative member countries in the region. The USA has the largest program and the largest scientific research base, the McMurdo station, built in 1956, which embarks up to 1300 people in the summer. In addition, they built the permanent Amundsen-Scott scientific station, strategically located at the Geographic South Pole (Mattos 2014). Although their Gross Domestic Products (GDP) are significantly lower than those of Brazil, Chile and Argentina carry out a greater volume of research activities. Russia has a structure inherited from

5 A dual-use activity is intended for two different purposes. In the case of Antarctica, these would be activities related to scientific research and military activities

6 The Antarctic Treaty Consultative Meeting - ATCM is held annually on a rotating basis among its members. This is a forum composed of representatives of the Antarctic Treaty, who deliberate on the establishment of standards for activities in Antarctica, in line with the principles and objectives of the Treaty (Brazil 2016).

the former USSR, going through a period of stagnation after the dissolution of the Soviet Union, but with a recent recovery.

China has a rapidly developing program, which began in 1964 and has seen a strong increase since 2008, with the establishment of specific policies for the region through the Polar Research Institute, subordinate to the Ministry of Land and Natural Resources. The country has a great interest in issues involving krill fishing and has recently opposed the establishment of environmental protection areas in the region. India's research program has accompanied the country's economic growth, which characterizes a stance of non-alignment with the international use of the continent and has revisionist actions for the region (Aguiar and Mattos 2018).

Table 1 – Comparison between Antarctic programs

Countries	Consultative Member	Permanent Stations	Seasonal Stations	Other Facilities[7]	Total
USA	Yes	3	0	4	7
Russia	Yes	7	5	0	12
China	Yes	2	1	1	4
India	Yes	2	0	0	2
Chile	Yes	3	7	2	12
Argentina	Yes	6	7	0	13
Brazil	Yes	1	0	1	2

Source: Adapted from Andrade et al. (2018).

In relation to the Brazilian program for Antarctica, Mattos (2014) highlights that, in 1975, Brazil signed the Term of Adhesion to the Antarctic Treaty but could only have its membership as a consultative member with the right to vote ratified by the other consultative members, after scientific research was carried out in the region. Based on this, Brazil approved the Brazilian Antarctic Program and carried out, in 1982, the first scientific expedition in Antarctica. In 1983, Brazil was accepted as a consultative member, gaining voting rights. In 1984, the Comandante Ferraz Antarctic Station (EACF) was inaugurated.

Operation Antarctica (OPERANTAR) is made possible through the Navy and is carried out annually between the months of October and April, comprising the Antarctic summer. In this Operation, ships and aircraft from the Brazilian Navy and Air Force (FAB) logistically support research projects in the various areas of interest. The Armed Forces (AF) carry out flights to

7 Includes small stations, called refuges; airfields; laboratories; camps; and deposits.

transfer equipment and research personnel to collection sites, which can be located in the vicinity of the EACF itself, in refuges or in pre-established areas. The program is supported by the airstrip at the Chilean station Base Frei Eduardo Montalva (Andrade et al. 2018).

Antarctica was included in the National Defense Policy (PND) as part of the Brazilian strategic environment along with South America and the west coast of Africa (Brazil 2020). The PND highlights the existence of resources in the region that can be a reason for greed and international instability. Despite the fact that Brazil has not formulated territorial sovereignty claims in Antarctica, POLANTAR highlights the country's right to protect its direct and substantial interests, if the functioning of the Treaty is revised (Brasil 2022b). To this end, the country has invested in research and infrastructure, aiming to maintain the status of consultative member of the STA, with emphasis on the acquisition of NPo Alte Maximiano and the reconstruction of the EACF (Agostinho 2019; Andrade et al. 2018). Recently, the Navy announced the project to build a new Antarctic Support Ship, replacing the Oceanographic Support Ship Ary Rongel (Brazil 2022a).

Antarctica has a high potential for natural resources and a possible change in the exploration regime established in the Madrid Protocol will impact national interests in the region. Antarctica exerts a significant influence on the climate of the Southern Cone, affecting food security and Brazilian agricultural capacity. Furthermore, Antarctica is a critical point for international maritime trade, due to the various shipping routes that surround it. A possible imbalance in the equilibrium of power and the high demand for natural resources due to the growth and development of world society could encourage Russia, China and even India to promote actions and alliances in exchange for revisionist agendas in 2048, the revision year of the Madrid Protocol (Hashimoto 2018; Dodds 2019; McGee, Edmiston, and Haward 2022a).

3 International interests in Antarctica

The STA was able to maintain balance on the continent by avoiding conflicts and freezing territorial claims. This stability may "mask the climate of previous periods in which Antarctica and the Southern Ocean were sites of significant international discord" (McGee, Edmiston, and Haward 2022b). The Antarctic Treaty was created in a context of increasing incidents between territorial states, during global polarization between the USA and the former USSR, during the Cold War. The treaty emerged as a response to these circumstances and has been effective in achieving the objectives of keeping the continent free from conflicts and territorial disputes, non-militarized and

focused on scientific research.

Its structure finds a diplomatic solution that establishes a balance between persistent claims and the possibility of new requests. However, some devices that were sufficient at the time may not be as effective in the current context. Art. IV, for example, establishes the "freezing" of past claims and the non-extinction of rights to future claims. This device may be activated by one of the Contracting Parties and territorial claims may return to the agenda in 2048 (Hanessian 1960).

On the other hand, there are loopholes for the use of military capabilities on the Antarctic continent. Art. I allows the logistical use of equipment, bases, material and military personnel in support of research. This device may suffer distortions due to the interests of States, providing dual use of these capabilities and initiating a slow and veiled militarization of the continent. This could compromise the STA and fuel an arms race (Hanessian 1960; McGee, Edmiston, and Haward 2022b).

The global context is different from that in force during the signing of the Treaty. Climate change has reduced the thickness of the ice sheet, making navigation to the continent easier. New resource extraction technologies have made the exploration of Antarctica possible, economically viable and advantageous. The advancement of communications and technology for logistical support has made the Antarctic continent "closer" and "more accessible", increasing its geopolitical importance. Linked to these factors, the post-Cold War globalization process brought the development and growth of societies with a proportional increase in demand for resources and energy. Furthermore, new actors have emerged, generating another balance of power, which exert pressure for changes to the STA status quo (Hanessian 1960; McGee, Edmiston, and Haward 2022b).

Four main factors with the potential to foment disputes were highlighted by (Hanessian 1960; McGee, Edmiston, and Haward 2022b): mineral resources, fishing, maritime routes, and the ability to use Antarctic space for communications and satellite monitoring. The geological structure of Antarctica allows for the existence of minerals of important economic and strategic value, including rare earth minerals, oil and gas. New prospecting technologies may bring pressure on the Madrid Protocol, which in its Article 7 establishes that "any activity related to mineral resources is prohibited, except scientific research" (Hanessian 1960).

Fishing can become another source of conflict. Krill in particular, in addition to species such as Patagonian toothfish, have been sought after by China and Russia. Activities are regulated by the Commission for the

Conservation of Antarctic Marine Living Resources[8]. The CCAMLR establishes a total catch quota by area, species and locations for fishing fish and krill. However, China and Russia have exploited their veto power in ATCM to block the creation of an environmental protection area and increase restrictions that could impact their activities in the region (Aguiar and Mattos 2018).

The Antarctic Ocean can be used as a maritime route between the Pacific, Atlantic and Indian oceans. New navigation technologies, with ships with greater autonomy and capacity, together with the increase in global trade, generate increased demand and consequently congestion on maritime routes. The experience of sailing in the Antarctic seas makes passage through the oceans of the Antarctic Treaty Area an important alternative (Pereira 2013; Visentini 2022).

Several research stations in Antarctica are operated by the military and may contain dual-use equipment, civil and/or military. (McGee, Edmiston, and Haward 2022b) cites the use of modern drones for surveillance, with high autonomy and great range, as another challenge to STA. These systems would initially be used for maritime surveillance, supporting search and rescue operations, monitoring fishing in the Southern Ocean and monitoring compliance with the Antarctic Treaty. There is, however, the possibility of using drones with military capabilities (i.e. transporting weapons) and monitoring facilities, which would constitute a violation of the terms of the Antarctic Treaty. In the past, Germany, Norway, the United States, Russia, India and Japan have operated satellite ground receiving stations on the continent. Currently, China and Russia are interested in expanding the coverage and accuracy of their global positioning systems, the BeiDou and Global Navigation Satellite System (GLONASS) networks, respectively. These networks are alternatives to the global positioning system (GPS) and can similarly support military firing guidance systems, for example (McGee, Edmiston, and Haward 2022b).

The strategic interests of some countries are also aligned with this context of militarization of the Antarctic continent. The USA has been part of the Antarctic Treaty since the beginning, positioning itself as the leader of the system. They invest huge resources in research in the region and have primacy in the number of stations, bases and human resources. Russia has a long history on the continent, having inherited the legacy of the USSR's Antarctic program, which has always presented a consistent policy for the region, with investments on different bases. From the 2000s onwards,

8 The 1980 CCAMLR Convention, which established CCAMLR, includes major distant-water fishing states and supranational organizations such as China, Russia, Japan, South Korea, the United States and the EU, as well as emerging states in developing Brazil, India and South Africa (McGee, Edmiston, and Haward 2022b).

Russia sought to reoccupy its prominent position on the international scene, prioritizing resources for the Antarctic project (Witker 2015; Makuc 2018).

Russia has shown special interest in krill fishing and activities aimed at expanding the region's use, revitalizing its fishing fleet in distant waters to increase revenue from seafood exports (Boulègue 2022). Russia considers Antarctica to be a space of geopolitical, geoeconomic and geoscientific competition, in which its interests need to be safeguarded and protected – just as in the Arctic – including by military means. In this context, Boulègue (2022) highlights that Russian scientific research can mask resource prospecting activities and intelligence and surveillance activities.

China has a high potential for imbalance in the STA, due to its growing protagonism and its initiatives in shaping treaties to its interests (Young 2021). In its five-year plan (2016-20), China declared its intention to review the governance of new fields of activity, which include the polar regions, with the aim of becoming a "polar power" (Aguiar and Mattos 2018). China has been exploring fishing and tourism in the region, in addition to showing the potential to lead a coalition of states in search of mineral wealth. Its interests on the continent include new shipping routes, mineral extraction and the use of the Antarctic aerospace environment for positioning satellites. China has sought to consolidate these interests through huge investments in the logistics of its program, with an increase in the number of bases, ships and research (Young 2021).

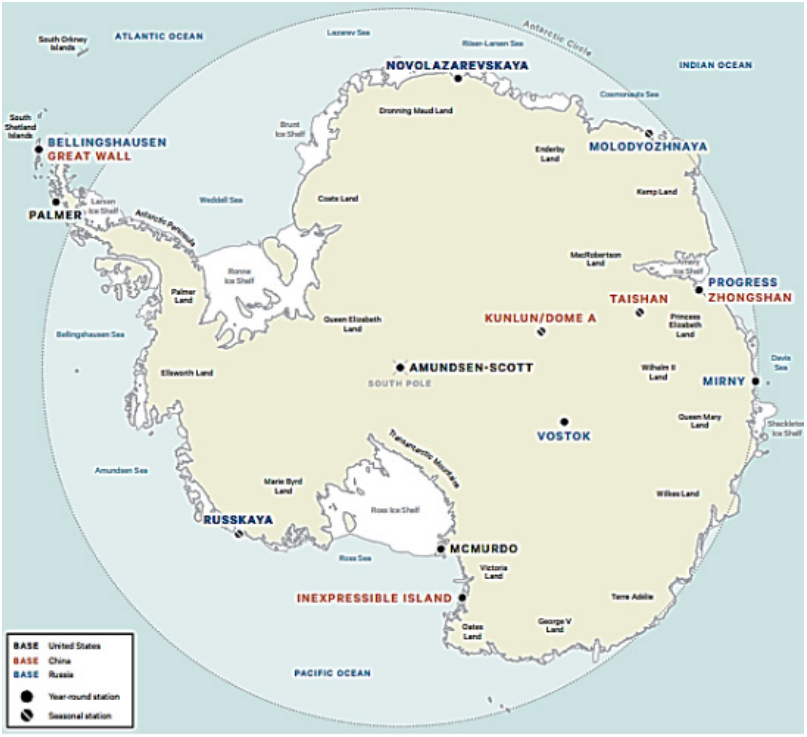
When the Treaty was created, India adopted a stance of non-alignment with other countries, opting not to join the TA and focus on the internationalization of the Antarctic continent. At that time, the Indian program made little progress, due to low economic development and low priority for research, as the country was involved in internal disputes in the post-colonial period. Subsequently, with the country's economic growth, associated with the demand for resources, the country changed its political stance towards the region. More recently, the Indian Antarctic program has made significant progress, currently having three permanent stations. Despite advances, dependence on external logistical support still represents a weakness in its program, as the Indian Navy does not have polar ships and research depends on outsourcing air support (airstrips and aircraft). As part of its foreign policy, the country has sought to increase its influence related to the governance of Antarctica, through alliances, including the Quadrilateral Security Dialogue (QUAD)[9] and the Logistics Exchange Memorandum of

9 The Quadrilateral Security Dialogue (Quad) was created in 2007, forming an informal strategic group with the USA, Japan, Australia and India, representing a diplomatic reaction to contain China's growing economic and military influence in the Indo-Pacific region. The group

Agreement (Logistics Exchange Memorandum of Agreement - LEMOA)[10] (Aguiar and Mattos 2018; Rai 2018).

The distribution of research stations in the USA, Russia and China, presented in Fig. 2, shows the extent and geographic breadth that these countries occupy on the Antarctic continent. This allows us to infer the difficulty of converging claims related to any theory of claim in the region. The growing installation of research stations may signal an embryo for future territorial occupation initiatives, something in the form of the legal principle "uti possidetis", according to which those who actually occupy a territory have rights over it. The current impossibility of territorial division of the continent can encourage alliances capable of putting pressure on the STA to make exploratory rules more flexible, which favor countries with a greater presence on the continent (Boulègue 2022).

Figure 2 – Main Russian, Chinese and North American installations in the Antarctic region



meets to exchange information and carry out military exercises.

10 The US defense cooperation agreement with India (Logistics Exchange Memorandum of Agreement - LEMOA) (Aguiar and Mattos 2018).

Source: (Boulègue 2022).

In South America, Argentina and Chile have robust Antarctic programs, consolidated territorial claims and great interest in the region, therefore being relevant on the continent's geopolitical board. These countries have the political and scientific capital to influence decisions that could impact eventual pressure for militarization of the region, as well as the possibility of extracting natural resources (Colacrai 2016).

The Brazilian program is consolidated, in line with the requirements established for ATCM consultative members. The Brazilian Navy has made recent efforts to improve logistical support for PROANTAR, through the acquisition of the Polar Ship Almirante Maximiano, the reconstruction of the EACF in 2019 and the construction project of the new polar ship, which will replace the NApAnt Ary Rongel. The average investment in scientific research in the Antarctic region has not been maintained over the years. In comparative terms, other countries have invested more in their programs, installing new research stations and equipping their Navies with ships with icebreaking capacity to operate in the region in any season of the year (Agostinho 2019; Andrade et al. 2018).

Article 25 of the Madrid Protocol establishes rules for modifications to the document, establishing a series of provisions that condition any change to consensus among members. Two situations for changes are described: until 2048, the Protocol can be modified at any time, as long as there is unanimity of the Consultative Parties; After 2048, any change requires approval and ratification by 75% of the States that were Consultative Parties to the TA in 1991. The Protocol further establishes that prohibitions relating to mineral resource extraction activities will remain in force unless a new regime is approved that regulates the subject (Hanessian 1960). Therefore, it is fair to infer that any changes to the exploration of mineral resources are more likely to occur through alliances than through imposition. The USA, Russia, United Kingdom, France, China, Japan and India would probably not accept impositions or changes that were not consensual.

4 Impacts of the Russo-Ukrainian War

The most immediate and noticeable impact of a conflict of this nature is evident in the economic environment. In a recent panel, the Federation of Industries of the State of São Paulo (FIESP) analyzed the impact of the Russian-Ukrainian War on some commodities, comparing variations in the prices of

the main raw materials, in the period from February 24 to March 18, 2022. Substantial increases were evident in the prices of Brent Oil (11.4%), Naphtha (11.4%), Iron Ore (a ton reached US$ 150.59), Coal (a ton reached US$334.50), Aluminum (highest price since 1995), Copper (highest price since October 2021) and Neon (main input for semiconductor production). The commercial isolation of Russia and Ukraine, large suppliers of commodities, burdened the supply chain of several other products, directly or indirectly affected (FIESP 2022).

Treaties and cooperation agreements tend to expand relations between countries. However, this logic is reversed during conflicts (Mbah and Wasum 2022; Khudaykulova, Yuanqiong, and Khudaykulov 2022; Orhan 2022). The Ukrainian War brought shocks to the economies of Russia and Ukraine, in addition to the economic blockade imposed by the West (Bergeijk 2022). The flight of investors, the increase in country risk, inflation and high interest rates have been other consequences. In addition to the direct impact on the economies of Russia and Ukraine, the risk of extension and expansion of the conflict brings a dampener to global trade, implying the regionalization of production chains and reduced efficiency. The restrictions with the closure of Ukrainian ports on the Black Sea compromise not only the local economy, but also global trade in wheat, sunflower oil, inputs for computer microchips and even for the production of vaccines. Russia also suffered strong commercial impacts with the departure of multinational companies and the interruption of services by several shipping companies. The economic sanctions imposed on Russia are unprecedented in scope and strength. Among them are: the closure of airspace for Russian companies, the ban on investments in the Russian economy, the freezing of foreign assets at the Central Bank of Russia and the exclusion of Russian banks from the Society for Worldwide Interbank Financial Telecommunications (Society for Worldwide Interbank Financial Telecommunication – SWIFT)[11] (Liadze et al. 2022; Irtyshcheva, Kramarenko, and Sirenko 2022; Orhan 2022).

The long-term impacts for Ukraine and Russia are incalculable. In addition to economic, commercial and productive capacity losses, the evasion of young people takes technological knowledge abroad. Russia may suffer tendencies towards isolation from Europe and closer ties with China. Europe will need to redirect its energy demand to other sources. China, which initially opted for a "veiled" alignment with Russia, may feel the impact of the withdrawal from European markets with possible consequences for its New

11 SWIFT is a network formed by banks from different countries aimed at carrying out international financial transactions. Created in 1973, it is headquartered in Brussels and is where most international interbank transactions are carried out.

Silk Road project (Ciuriak 2022).

Ciuriak (2022) interprets that there was an error in the West's assessment regarding the strength of the alliance between China and Russia. The agreement signed between China and Russia, in the six months before the invasion, recognized the countries' interests in Taiwan and Ukraine, respectively. This reinforces the strategic alignment of both, in which Russia seeks to regain territories belonging to its former area of influence and China seeks a geopolitical position favorable to its economic project. Putin defended the invasion of Ukraine on historical, religious and psychosocial grounds, claiming there was a Western war against Russia and the need to preserve the unity of the Slavic peoples. Although calculated, the war highlights undesirable consequences, related to the extended duration of the conflict, Ukraine's resilience and the economic impacts of Western sanctions, with a direct impact on the world economy.

Papanikos (2022) argues that there is more behind the conflict than Ukraine's rapprochement with NATO. In his argument, the Russian advance was intentionally leveraged by the US, by highlighting a supposed imminent invasion of Ukraine, reinforcing that it would not become militarily involved in the conflict. The North American intention would be to promote a resurgence of NATO, through cohesion against the Russian enemy and the consequent rearmament of its components and the disruption of Russian energy supplies to Western Europe. These objectives would aim to regain North American protagonism and increase its arms and energy industries (Papanikos 2022).

However, Ciuriak (2022) argues in the opposite direction to the US' supposed intention, highlighting that an immediate consequence of the war was criticism of the NATO system. For that author, the War in Ukraine brought new light to the debate about its impotence in the face of Russia's recent initiatives in Georgia (2008) and Crimea (2014). (Ciuriak 2022) considers that the rearmament of Germany and Japan, with the increase in military spending on acquiring new resources and equipment, is evidence of the low credibility of an alliance that would precisely have the objective of avoiding conflicts.

Even though the Ukrainian War did not reach the scale of a global conflict, its impacts transcend both countries. Commercial, economic, political and military blocs and alliances form the embryo of a reordering of the international system. This instability of the international system affects countries with territorial claims and non-scientific interests over the Antarctic continent, being analyzed by (McGee, Edmiston, and Haward 2022b), in The Future of Antarctica: scenarios from classical geopolitics. (Press 2022) also establishes a connection between Antarctic security and the invasion of

Ukraine, describing that polar governance suffers a growing double threat, arising from global warming and global geopolitical instabilities, in particular driven by the recent war. It is these cause-and-effect relations that this research intends to survey and analyze, using a methodological tool from Operational Research, aimed at this type of complex system.

5 Problem modeling

The research continued the work of McGee, Edmiston, and Haward (2022b). Those researchers initially raised 49 FMs that could undesirably impact militarization in Antarctica, being categorized into nine groups: Political, Economic, Social, Technological, Environmental, Legal, Geographic, Strategic and Historical. This set was later reduced to the 11 most relevant FMs, based on risk analysis criteria (degree of uncertainty and degree of importance), evaluated by experts. Each criterion was scored on a scale of 1 to 4, and the multiplication of evaluations determined the score for each Driving Force. Based on this final list, a new Driving Force was added to the Strategic group, the War in Ukraine, as shown in Table 2.

Table 2 – Driving Forces considered

Area/Field	Driving Force	Description
Political	P1 - Instability of the international system (relevant to the STA)	The instability of the international system, from the point of view of the Antarctic Treaty System (STA), can reduce the balance in international relations, given possible changes to multipolarity and power competition, particularly between China, Russia and the United States, with potential spillover effect to Antarctica.
Strategic	E1 - Strategic advantage of the militarization of Antarctica	The strategic advantage resulting from the military occupation of Antarctica and the Antarctic Ocean can encourage and expand non-peaceful activities in the region, damaging research and scientific activities.
	E2 - Ukrainian War	The War in Ukraine has caused political, economic and military changes in Eastern European countries, in Military Alliances and has influenced diplomatic and commercial relations in the international community, with a possible impact on the STA.
Technological	T1 - Use of receiving stations in Antarctica for military purposes	Development of global positioning systems leads to the use of receiving stations in Antarctica and the Antarctic Ocean to support military command and control activities and platforms.
	T2 - Link between receiving stations in Antarctica and military satellites	Development of military satellites that use receiving stations in Antarctica to link military communications.
	T3 - Use of infrared telescopes for military purposes	Development of infrared telescopes for target tracking and military surveillance.
	T4 - Use of UAVs for surveillance and aerial attack	Development of UAVs for deep aerial surveillance in Antarctica and with the ability to carry out air strikes.

Area/Field	Driving Force	Description
Environmental	A1 - Severity of the impact of climate change	The magnitude and speed of the increase in global average temperatures resulting from human activity (primarily greenhouse gas emissions) remains uncertain. Projections for the coming decades remain within a wide range, due to the considerable number of variables.
Legal	J1 - Degree of divergence from STA obligations	STA obligations restrict parties from militarizing Antarctica. Furthermore, some provisions of the treaty diffuse key issues with the potential to trigger militarization. In particular: Art. I prohibit military activity for non-peaceful purposes; Art. IV provides a mechanism to respect various positions on territorial sovereignty; and Art. 7 of the Madrid Protocol imposes a ban on mining in the region.
	J2 - Use of civil servants for military purposes	Some civilian research and the operation of ground-based receiving stations may represent non-peaceful use of civilian personnel and therefore constitute measures of a military nature. The lack of clarity in this area makes it difficult to detect violations.
	J3 - Countries' resistance to the inspection regime for detecting dual-use equipment	Inspection and monitoring practices under the Antarctic Treaty and the Madrid Protocol are infrequent and limited in scope. Inspection teams lack access and sufficient technical knowledge to identify whether certain types of scientific equipment are being operated for military purposes.
Geographic	G1 – Extension of ice sheets and restriction of access to land and sea areas	The presence of thick ice sheets, glaciers and gullies across 98% of the continent's surface, along with sea ice and icebergs around the continent's coasts, are challenging to maritime access to the continent and logistics, requiring high-value specialized equipment such as icebreaker ships.

The interactions between these 12 FM were modeled using the Fuzzy Cognitive Maps method. The method provides for the generation of a visualization (map) for analyzing mental projections (cognitive) through criteria valuation (fuzzy).

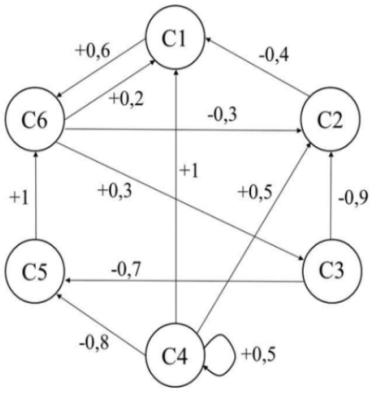
A cognitive map is a structure used to graphically present the cause-and-effect relations between several important concepts in a problem (Kosko 1986). The map traces a "mental perspective" of an individual, allowing the "impact power" of these relations to be calculated through numbers in the range [0,1] or [–1,1] (Yousefi, Jahangoshai Rezaee, and Moradi 2020). These mental representations change continuously and any attempt to capture them will modify them; they are, therefore, inaccessible to the researcher. In this way, the map does not accurately model cognitive representations, but rather perceived relations and serves as a tool to support analysis and the decision-making process.

Although FCM are a derivation of cognitive maps (CM), there are differences. Both are graphical tools that model an individual's cognitive (or mental) representations, seeking to explicitly represent influence or causality between variables in order to assist the decision-making process. FCMs differ from CMs in that they evaluate concepts and their causal relations through mathematical modeling, which includes fuzzy logic and neural networks.

FCMs have applications in several fields, such as: analyzing and predicting decisions; identify variables in a system for control and monitoring and support the decision support process. The first step in creating a cognitive map is the survey of variables derived from the experience and knowledge of experts in the field under study, from which concepts and causal relations can be traced. Obtaining this information can be done through statements, interviews and questionnaires. The main components of the FCM are the nodes and arcs that represent, respectively, concepts and interconnection relations. These arcs symbolize relations of influence/causality. A positive sign associated with the arc indicates that the increase in one concept will imply an increase in the other related concept. The negative sign indicates that the increase in one concept will influence the decrease in the other related concept (Sperry and Jetter 2019; Shahbazi 2022; Yousefi, Jahangoshai Rezaee, and Moradi 2020).

When modeling an FCM, the problem concepts are called Ci, where i varies from 1 to N, with "N" being the total number of concepts. The arcs are assigned weights that show the intensity of the impact. These arc weights, called wij, vary in the range [0, 1] or [–1, +1] and are arranged in an N x N matrix, called Adjacency Matrix. The cause-and-effect relations of the Adjacency Matrix are directed from row i to column j. For example, the C1-C6 relations are represented by a weight w61 = +0.6, thus being indicated in the matrix, while the C1-C6 relations, represented by w61, have a value of +0.2. Fig. 3 shows an example of an FCM with its adjacency matrix, representing the causal relations between the concepts of a problem (Papageorgiou et al. 2020).

Figure 3 – Example of an FCM with its Adjacency Matrix



$$W = \begin{array}{c} \\ C1 \\ C2 \\ C3 \\ C4 \\ C5 \\ C6 \end{array} \begin{array}{c} \begin{array}{cccccc} C1 & C2 & C3 & C4 & C5 & C6 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0{,}6 \\ -0{,}4 & 0 & 0 & 0 & 0 & 0 \\ 0 & -0{,}9 & 0 & 0 & -0{,}7 & 0 \\ 1 & 0{,}5 & 0 & +0{,}5 & -0{,}8 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0{,}2 & -0{,}3 & 0{,}3 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

Source: Adapted from (Papageorgiou et al. 2020).

According to (Papageorgiou et al. 2020), the following steps are necessary to create an FCM:

- selection and numbering of concepts (Ci) that will be objects of analysis;

- definition of the causal relation between concepts; and

- determination of the strength of the impact between concepts;

The intensities of the impacts (w) of the causal relation between the concepts and the type of impact (positive or negative) are essential for assembling an FCM:

- wij = 0, there is no causal relation between concepts;

- wij > 0, causal increase (Cj increases as Ci increases and Cj decreases as Ci decreases);

- wij < 0, causal decrease (Cj decreases as Ci increases, and Cj increases as Ci decreases).

Table 3 presents reference values for the intensity of the impact of cause and effect relations between concepts.

Table 3 – Measures of fuzzy causal relations

Cause-effect relations between variables	Numeric values
Very strong increase (attenuation)	0,9; 1 (-0,9; -1)
Strong increase (attenuation)	0,7; 0,8 (-0,7; -0,8)
Moderate increase (attenuation)	0,5; 0,6 (-0,5; -0,6)
Weak increase (attenuation)	0,3; 0,4 (-0,3; -0,4)
Very weak increase (attenuation)	0,1; 0,2 (-0,1; -0,2)
Null (absence of relation)	0

Source: Adapted from (Papageorgiou et al. 2020).

The problems that are submitted to decision makers are not composed of variables that remain static, therefore generating a changeable environment where FM interact dynamically (Papageorgiou et al. 2020). Under the scope of artificial intelligence, a series of inferences generate continuous changes in variables, based on values initially assumed for concepts and the arcs of interconnection between them. Initially, concepts receive values Ai(k), which vary in the range from 0 to 1, being "0" when the concept does not exist at the

initial moment and "1" when it is complete. The calculation of the following values Ai(k+1) is done using inference rules, the most common of which are: (1) Kosko inference, (2) modified Kosko inference and (3) rescaling inference, according to Equations (1) to (3).

$$A_i(k+1) = f\left(\sum_{j=1, j\neq i}^{N} w_{ij} \cdot A_j(k)\right) \quad (1)$$

$$A_i(k+1) = f\left(A_i(k) + \sum_{j=1, j\neq i}^{N} w_{ij} \cdot A_j(k)\right) \quad (2)$$

$$A_i(k+1) = f\left((2 \cdot A_i(k) - 1) + \sum_{j=1, j\neq i}^{N} w_{ij} \cdot (2 \cdot A_j(k) - 1)\right) \quad (3)$$

Value variations are calculated by the function f (.) and can be: (4) bivalent (takes only two values), (5) trivalent (takes only three values), (6) sigmoid or (7) hyperbolic tangent, as per shown in Equations (4) to (7), respectively.

$$f(x) = \begin{cases} 1, & x > 0 \\ 0, & x \leq 0 \end{cases} \quad (4)$$

$$f(x) = \begin{cases} 1, & x > 0 \\ 0, & x = 0 \\ -1, & x < 0 \end{cases} \quad (5)$$

$$f(x) = \frac{1}{1 + e^{-\lambda x}} \quad (6)$$

$$f(x) = \tanh(\lambda \cdot x) \quad (7)$$

The slope of the continuous function f is established by a positive real number ($\lambda > 0$) and the value of the concept in the initial state Ai(k) is represented by x. It is important to highlight that the sigmoid function guarantees that the calculated value of each concept will belong to the interval [0, 1]. The hyperbolic tangent function can replace the sigmoid when the values of concepts can be negative, receiving values in the interval [-1, 1].

6 Expert reviews

From the set of 144 cause and effect relations of the 12 FM, fifteen FM were considered evident, regarding the direct or indirectly proportional relations and the directionality of the relations. These fifteen relations were hidden from experts, so that they could be used as a factor to validate judgments. Thus, if an expert coincided his assessments with the factor, the quality of his judgments would be 1 (equivalent to 15/15), another who agreed

on 12 out of 15 relations, the quality would be 80% (equivalent to 12/15), following the other calculations. From an initial list of 28 Experts, 11 obtained accuracies equal to or greater than 80%, and the matrix in Table 4 was then created, using the weighted average of their evaluations.

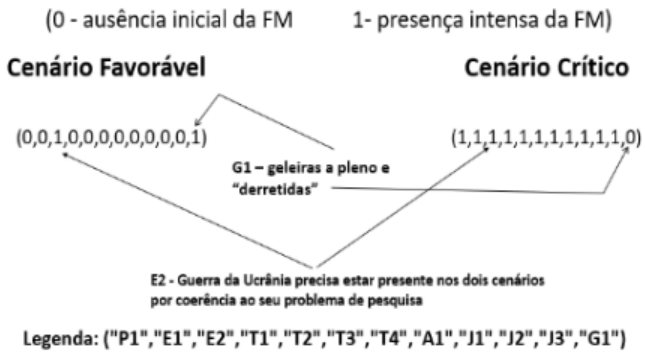
Tabela 4 – Matriz Resultante

Forces	P1	E1	E2	T1	T2	T3	T4	A1	J1	J2	J3	G1
P1	0,0458	0,4633	0,4629	0,3079	0,3383	0,2958	0,2792	0,1663	0,4563	0,3050	0,4413	-0,0004
E1	0,5163	0,0458	0,1183	0,5692	0,6204	0,5233	0,5108	0,0833	0,5642	0,4333	0,5113	-0,1246
E2	0,6471	0,3288	0,1013	0,2483	0,2346	0,3050	0,3213	0,0321	0,1217	0,2925	0,3550	-0,0825
T1	0,4442	0,4946	0,1733	0,0458	0,6958	0,4783	0,4583	0,0442	0,4250	0,4754	0,5596	-0,0758
T2	0,4400	0,5000	0,1596	0,6350	0,0458	0,4546	0,4167	0,0300	0,3225	0,4704	0,4771	-0,0079
T3	0,3625	0,4575	0,2546	0,3950	0,3638	0,0458	0,3563	0,0175	0,2971	0,3642	0,4283	-0,0858
T4	0,3921	0,4713	0,1246	0,4421	0,4475	0,4238	0,0458	0,0079	0,3063	0,3825	0,4667	-0,0446
A1	0,3608	0,1546	0,0000	0,0296	0,0113	0,0058	-0,0079	0,1083	-0,1075	0,0979	-0,0646	-0,0496
J1	0,4242	0,3850	0,0721	0,2429	0,3100	0,2808	0,2879	0,2158	0,0458	0,3283	0,5513	-0,0575
J2	0,3358	0,3704	0,0863	0,2917	0,2967	0,2758	0,2808	0,0092	0,2992	0,0458	0,3850	-0,0567
J3	0,4704	0,4125	0,1879	0,4092	0,4463	0,4546	0,5046	0,1092	0,5013	0,3379	0,0458	-0,0104
G1	-0,1525	-0,1821	-0,0200	-0,1125	-0,0892	-0,0988	-0,0392	-0,2092	-0,2842	-0,1738	-0,1804	0,0458

7 Initial scenarios for modeling the algorithm

The initial states of the FM were adjusted in two scenarios: one favorable and one critical. The initial values for each FM are "1", when the FM is considered "full" in the scenario, and "0", when the FM is considered absent or "null". The favorable scenario considers that the FM harmful to the STA and driving trends towards the militarization of the Antarctic continent are initially null, receiving a value of "0". The critical scenario reverses this logic. FM G1, which concerns the increase in the extent of ice sheets with the consequent restriction of access to land and sea areas, assumes inverted values, being "1" in the favorable scenario and "0" in the critical one. FM E2 referring to the Ukrainian War starts with a value of "1" in both scenarios, for consistency with the research objective. Fig. 4 illustrates the arrangement of values according to the scenarios.

Figure 4 – Initial state of interactions between Driving Forces



* Respectively: 0- initial absence of FM 1- intense presence of FM; Favorable Scenario Critical Scenario; G1- Glaciers in full and melting; E2- The Ukraine War needs to be present in both scenarios for coherence to your research program; Subtitle.

To carry out the inferences of the fuzzy cognitive map, the "FCM" application of the R software was used, considering the initial values of the two scenarios and the dynamics of interactions by rescaling equation, which recorded the final FM equilibria with the greatest number of stages, with six steps for each scenario (Dikopoulou and Papageorgiou 2017).

The results of the interactions indicate values assumed by the FM, between 0 and 1, indicating an increase or decrease in strength or performance in the system, in relation to the initial values established in each scenario. To make the interpretation coherent and facilitate the analysis of the results, the 12 FM were separated into four groups: political-strategic (P1 and E1); scientific-technological (T1, T2, T3 and T4); legal (J1, J2 and J3) and environmental (A1 and G1).

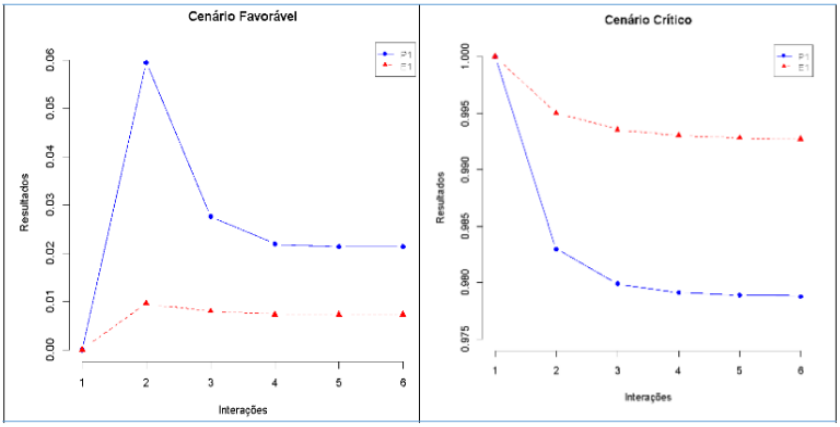
When evaluating the interactions of the Resultant Matrix, the ability of one FM to influence the other (from row to column) and the extent to which each FM is influenceable was considered. In the calculation, absolute values were considered since there will be a positive or negative influence. The FMs with the greatest capacity to influence are E1, T1, T2 and J3. And the most influenced are E1, J3 and T3.

8 Results

The results were analyzed by sets of political-strategic FM (P1 and E1), scientific-technological FM (T1, T2, T3 and T4), judicial-legal FM (J1, J2 and J3) and environmental FM (A1 and G1). The graphs in Figs 5, 6, 7 and 8 show the dynamic behavior of the interactions, which reached equilibrium in the

sixth stage. In the favorable scenario, these undesirable FMs start in a null state ("zero" value), indicating their absence at the beginning of interactions. In the critical scenario, these forces start with a maximum value of "1", indicating their full presence at the beginning of interactions. The values on the vertical axis show the intensity of the driving force in each stage until its stabilization. The equidistance between the six stages are just to simplify the graphical visualization, as it is not possible to infer how long each stage can last, depending on the complexity of the system, its multiple interactions and the freedom of action of the actors involved.

Figure 5 – Political-Strategic Driving Forces (P1, E1)[12]

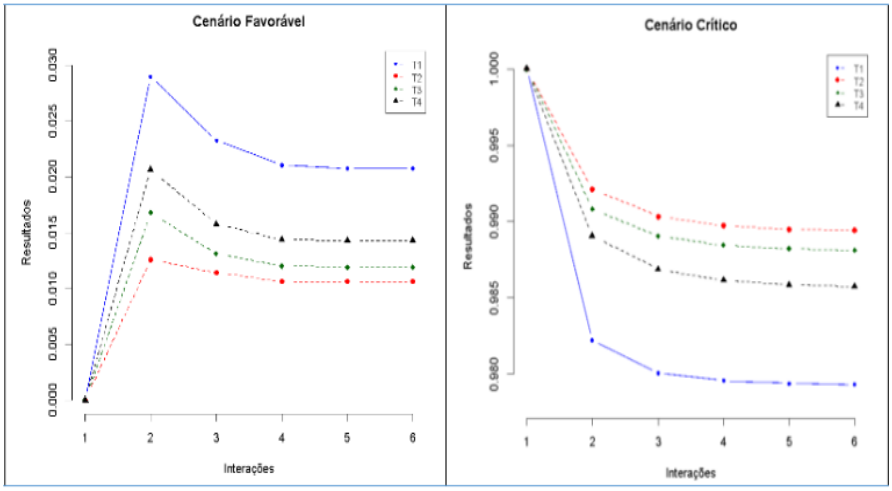


Analyzing the political-strategic FM, it is noted that in a favorable scenario both FM would have a small initial variation that would later stabilize at low values. The instability of the international system in this case would have a greater initial variation indicating the pressures on the adjustment of the international system. However, in this case the impact of the Ukrainian War would not cause major disruptions. In the critical scenario where FM would begin at its maximum level, the advantage of the militarization of Antarctica (E1) would barely suffer a reduction, indicating a constant increase in the deployment of resources and personnel for dual use. The instability of the international system (P1) also remains at high levels, indicating that the War in Ukraine can generate impacts that go beyond the regional level. It therefore seems sensible to observe the development of the War in Ukraine and its consequences, being aware that even if FM P1 and E2 are not at full strength in the real situation, they are at high levels, closer to the critical scenario, so they do not tend to have great attenuation. Analyzing the current

12 Translation: Favourable Scenario; Critical Scenario; Results; Interactions

moment of instability in the international system, the FM's behavior would be closer to the critical scenario than the favorable one.

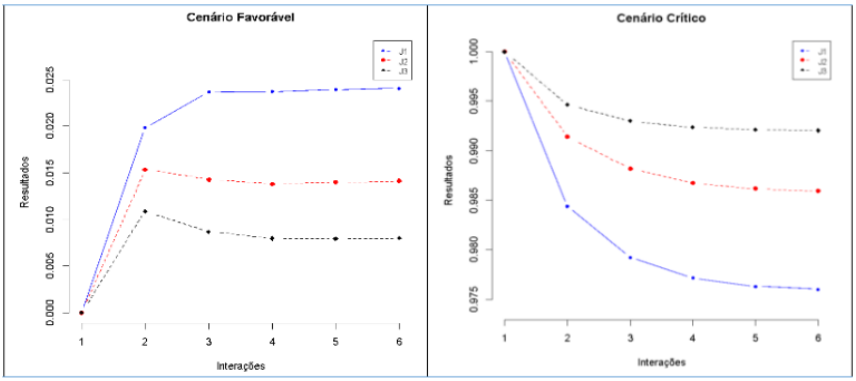
Figure 6 – Scientific – Technological Driving Forces (T1, T2, T3 and T4)[13]



Considering scientific-technological FM, it can be seen that in the favorable scenario all FM would present a relatively small initial boost (1.5 to 2.5%) with subsequent reduction and stabilization at low levels indicating the permanence of existing technologies, therefore they would not be null, but without dual use. The sequence of values T1, T4, T3 and T2 would indicate the greater development and dissemination of the technology, which is coherent when analyzing T1, which represents the use of receiving stations whose value is preponderant as it is the basis for the other technologies. When checking the unfavorable scenario for these same FMs, a small initial attenuation (between 1 and 2%) is noted, followed by stability at high values close to full use of technologies. This would mean that current capabilities already used in a dual manner would have their military bias expanded. The sequence of values T2, T3, T4 and T1 indicates which technologies would be most used. In this case, the evolution and impacts of War in Ukraine may establish the levels of use of these technologies as well as the maintenance of their use exclusively in scientific activities or their use for military use.

13 Translation: Favourable Scenario; Critical Scenario; Results; Interactions.

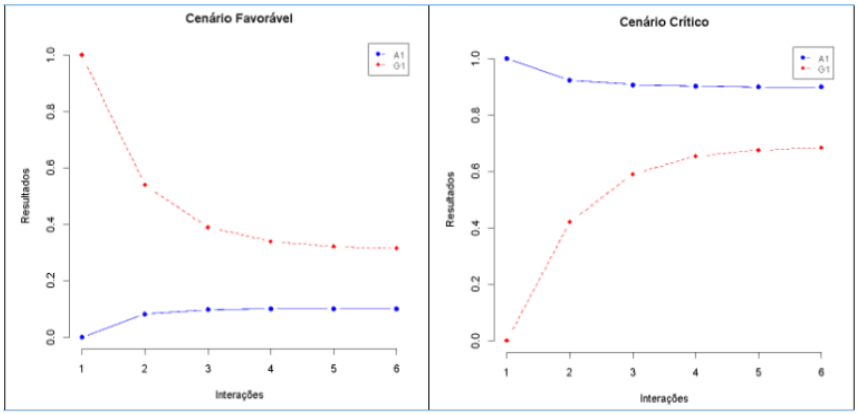
Figure 7 – Judicial-legal Driving Forces (J1, J2 and J3)[14]



Judicial-legal FMs show similar evolution to other FMs in the favorable scenario: small initial increase and subsequent stabilization at low levels. It is worth highlighting the prominence of J1, which deals with the degree of divergence between countries regarding compliance with STA obligations, as even in a favorable scenario it stands out in values indicating initial divergences between interested states. In a critical scenario, attenuation is small and levels remain high. In this scenario, FM J3 draws attention as it would represent the first indication of irregular activities due to the increased resistance of countries to inspections. If a tendency for the War in Ukraine to continue, although it is relevant not to reach catastrophic levels with the involvement of several countries, there is a tendency for J1, J2 and J3 to remain at at least intermediate levels, not favoring the balance of the STA but not necessarily being disruptive.

14 Translation: Favourable Scenario; Critical Scenario; Results; Interactions.

Figure 8 – Environmental Driving Forces (A1 and G1)[15]



Environmental FM, in turn, presents different behaviors from the others. In the favorable scenario where G1 is set to value "1", that is, "full", as a large extension of the ice layer is desirable, the FM suffers great attenuation (more than 60%) which is understandable given that the time for this type of climate change is relatively long. On the other hand, A1, which represents the severity of the impact of climate change, has a small increase, indicating the little relevance of these changes in a favorable scenario. For the critical scenario, the opposite occurs, climate change is of great importance in the militarization of the continent as well as the reduction of ice sheets.

From the analysis of the data resulting from the application of the FCM to the values originating from the weighted average of the experts' adjacency matrices, it can be noted that the Ukrainian War will be a catalyst for the FM, influencing the possible militarization of Antarctica, since its existence, considered for both scenarios, changes the FM values. The intensity of the changes will depend on the evolution of the conflict and whether it will be restricted to the regional level or will spread not only in space, but in other areas.

9 Conclusion

The research aimed to analyze the possible impacts of the Ukrainian War on the balance of power between nations and how it could be a motivator for revisionist actions by the great powers, based on militarized dual-use structures, on the occasion of the STA analysis, scheduled for 2048.

Initially, the topic was contextualized, showing the characteristics of Antarctica that made it relevant to the point of being included in the Brazilian

15 Translation: Favourable Scenario; Critical Scenario; Results; Interactions.

Strategic Environment according to the LBDN and PND. POLANTAR was also presented as a guiding standard for Brazilian objectives in the region, its guideline that points to the defense of the exploration of Antarctica exclusively for scientific research purposes, implementing the provisions of AED 83 of the END. This initial part is important for offering an understanding of the country's objectives for the sixth continent, serving as a guide for research on the topic.

Then, for a better understanding of the work by the reader, the research problem, the final objective and the intermediate objectives whose achievement leads to the solution of the first presented. Additionally, justifications for establishing the scope that delimited the research were presented, as well as the information that makes it relevant for study. Still in the initial chapter, the organization of the research was explained, facilitating the understanding of the sequence of the work.

The literature review, presented below, presented the two main study themes: the geopolitical balance of the STA and the War in Ukraine. The work used the theoretical basis of the research by McGee et al. together with the fuzzy cognitive maps method to analyze possible interactions. Aiming to meet this objective, a summary of the work by McGee et al. and the point at which our research settled was indicated.

Next, the research dealt with the history of the continent, citing the evolution of the level of interest in the region. From the period of relative abandonment, lack of knowledge and lack of interest motivated by technological difficulties in access, permanence and navigation, going through a period of still incipient interest where only a few nations sought to establish objectives on the continent through territorial claims when the first disputes arose. This initial analysis was fundamental to better understand the power disputes that made necessary the construction of the STA.

Elsewhere, the process of evolution of the international system since the end of the Cold War, when the USA emerged as the only power and leader of the neoliberal globalization process, establishing the period of Pax Americana, is explained. The factors that led to the end of North American unipolarity were then presented. They contain the origins of multipolarity, the process of deglobalization and the reorganization of production chains. The origins of the Ukrainian War and how it brought about a worsening of the relationship between the USA and Russia were also presented. It also showed that China's non-alignment with other Western powers in favor of sanctions on Russia was another stress factor for the international system. These factors help explain the current instability in the international system and how it could spread to other important strategic regions such as Antarctica.

This set of circumstances generates the need to investigate how this

intensification of tensions can influence Brazil, especially on the Antarctic continent. The investigation was carried out using the Fuzzy Cognitive Maps methodology. It was described how the concepts and relationships of cause and effect were submitted to the experts. It was also explained how the input values for the R interaction software were generated from the Adjacency Matrix resulting from the weighted average of the Questionnaires. The resulting graphs were then presented, the analysis of which allowed the assessment of the impact of the War in Ukraine on militarization and consequently on the balance of the STA.

From the analysis of the graphics, it can be seen that regardless of the chosen scenario, whether the "critical" one when the FM favorable to militarization are at full strength or the "favorable" one when the FM favorable to militarization are null, the War in Ukraine brings about a change in the initial values, that is, it influences the system. The difficulty in developing the prospective scenario is due to the fact that the conflict is ongoing and could still be expanded or distended. The intensity of changes in FM and consequently in the International System depends on the evolution of the conflict and whether it will remain restricted to the regional level or will spread.

Another relevant aspect is that the War in Ukraine exposed weaknesses, dissolved treaties and generated new alliances. Furthermore, it showed the fragility of the world production system and its need for reorganization. By reorienting alliances and exposing divergences, the main global actors turned their attention to issues of national sovereignty, militarization, regional production and the search for new trade opportunities and sources of resources. At this point, within some market possibilities, Africa emerged and among some possibilities for resource sources, the Arctic and Antarctica gained relevance.

Leaders and strategic thinkers have the responsibility to reflect and prepare for the future before it arrives, this is called strategic planning. The revision of the Madrid Protocol in 2048 may arise from an alignment of interests of new and old actors. It is a plausible scenario and should be considered especially by Brazil, which has Antarctica as part of its strategic environment. However, it is noted that the conflict already influences the balance of the global balance of power and is a candidate to be a catalyst for change with the potential to influence changes in the Madrid Protocol. Some of these new positions are ongoing and the extent to which they will reach will depend on the future of the conflict. Among them we mention: resumption of the US and NATO's leading role, rearmament of EU countries, regionalization of the production chain, reduction in the pace of global growth and isolation of Russia from the West with consequent rapprochement with China, among

others.

The evolution of the conflict in Ukraine and its impacts require constant analysis of the international context to identify the position that the country should and can adopt in view of its interests and mainly its National Power to, subsequently, establish the directions for national strategy in a world moving towards multilateralism. In this sense, it is more interesting and more effective for the country to maintain its historical stance of conciliation and establishment of transnational alliances.

In this way, the work in question achieved the purpose of analyzing possible geopolitical impacts resulting from the Ukrainian War on the stability of the STA that could encourage the militarization of the continent. The limitations of the research imposed the need to establish a cut in the analysis of the aspects considered most relevant. In this way, the following improvements are visualized:

- the extension of this work by using the other FM listed in McGee's original research;

- expansion of the specialist group, diversifying into other areas of activity;

- assessment of the applicability of the study in the analysis of conflicts similar to the one considered here; and

- the study of expanding the Brazilian Antarctic Program, defining priority areas and projects for investment as well as evaluating the possibility of expanding the program's logistical capacity by building new stations and increasing the number of research projects

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ABSTRACT

The purpose of this article is to evaluate the impact of the Ukrainian War on the geopolitics of Antarctica. Beyond the borders of the countries involved, the most immediate and noticeable impact of a conflict of this nature is evident in the economic environment. However, international relations are tested or shaken, exerting pressure on treaties and cooperation agreements between countries, through the reappearance of past political issues. In 1959, the Antarctic Treaty sought to protect the continent from territorial pressures capable of affecting its natural balance, but this type of conflict compromises international cooperation and brings to light old interests in resource exploration in that region. This complex system, composed of cause and effect forces that involve the interests of the different countries involved in Antarctic geopolitics, was quantitatively modeled by cognitive maps, which explore artificial intelligence concepts to evaluate the behavior of these forces. The results indicated trends in relation to 12 driving forces selected from the literature and evaluated by experts from the Brazilian Antarctic Program, allowing the evaluation of the dynamics of the system over time.

KEYWORDS

Ukraine war; Geopolitics of Antarctica; Fuzzy Cognitive Maps.

Received on December 10, 2022
Approved on May 29, 2023

Translated by the authors